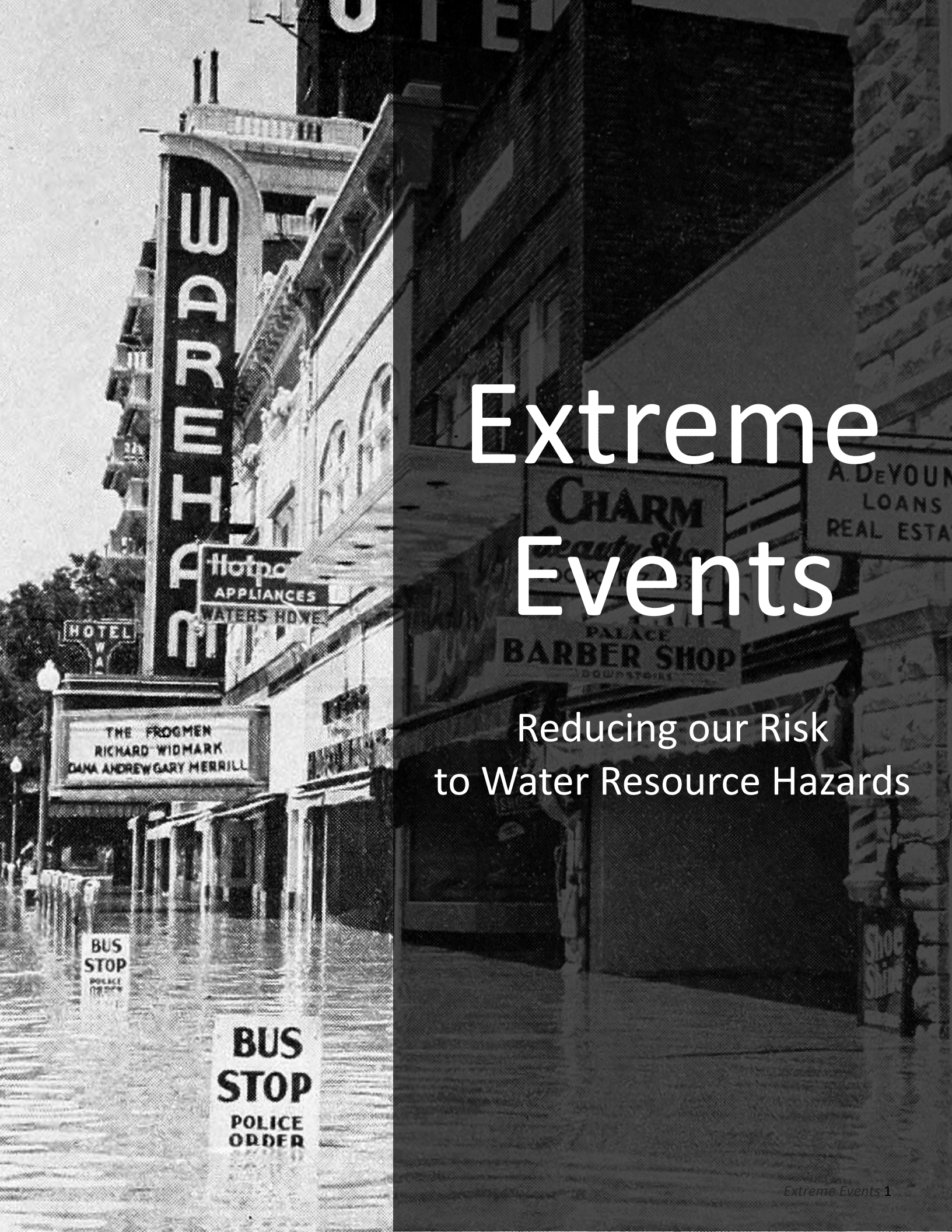


Extreme Events

Reducing our Risk to Water Resource Hazards

Background & Issue

Extreme weather events impact Kansas regularly. Severe flooding occurred in Kansas in 1935, 1951, 1965, 1973, 1976, 1981, 1983, 2007, 2011 and again in 2019. Kansas has also repeatedly experienced droughts, with most aware of the "dirty thirties" and the 1950s drought, and while these events have typically been used as standards for severe droughts in Kansas in the past hundred years, paleoclimate proxy evidence indicates droughts in Kansas of even greater severity and duration over the past thousand years. The state's diverse climate and propensity for both extremely wet and dry conditions creates unique challenges. In some years, both flooding and drought can occur simultaneously, as they did in 2011 when above-average snowpack melt and precipitation impacted the Missouri River system and caused northeast Kansas to flood while much of the state was in a moderate to exceptional drought.

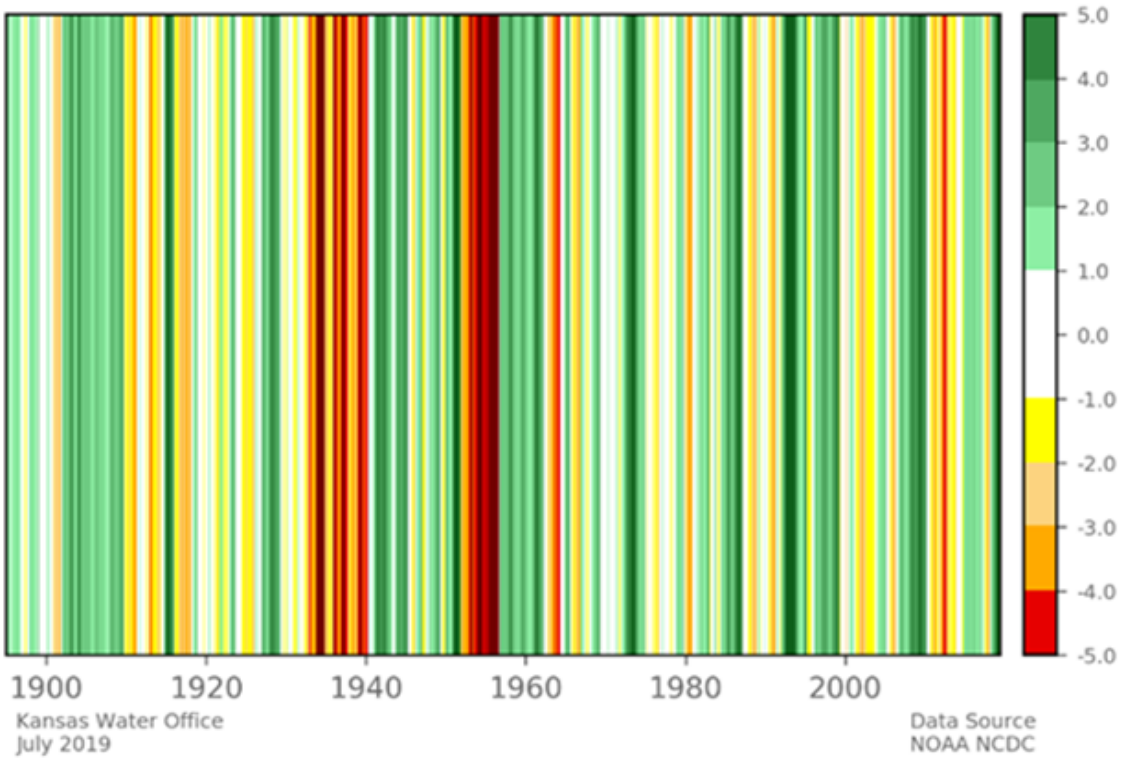


Figure 1. Historical Kansas Palmer Drought Severity Index (PDSI) values.
PDSI utilizes precipitation, temperature, and available water content data to estimate relative dryness. Classifications typically range from extremely wet (PDSI > 4.0) to extreme drought (PDSI < -4.0). Historical PDSI data illustrates the year-to-year variability of water resources in Kansas, as well as the severity of extreme events like the 1930s and 1950s droughts.

Climatologists have warned that Kansas is facing a warming trend in our future, causing a potential increase in the frequency, duration, and intensity of extreme events. Recent decades support this trend, with temperature increases particularly notable in the spring, which affects the planting of crops. The Fourth National Climate Assessment, 2018, projects that current temperatures will increase in the Southern Great Plains by 4.4 to 8.4 degrees Fahrenheit by 2100. Even small increases in average temperatures raise the risk of heat waves, wildfires, and droughts, as well as higher surface water evaporation and more turbulent atmospheric conditions leading to severe weather.

Future predictions for average annual precipitation are somewhat uncertain, with projections indicating a slight increase in winter precipitation and decrease in summer precipitation. However, the anticipated increase in the frequency and intensity of extreme precipitation events could result in decreased soil moisture, as soil would have less time to absorb the precipitation and longer periods between precipitation events to dry out. Such conditions would have a direct, negative impact on agriculture and put a greater strain on flood management infrastructure.

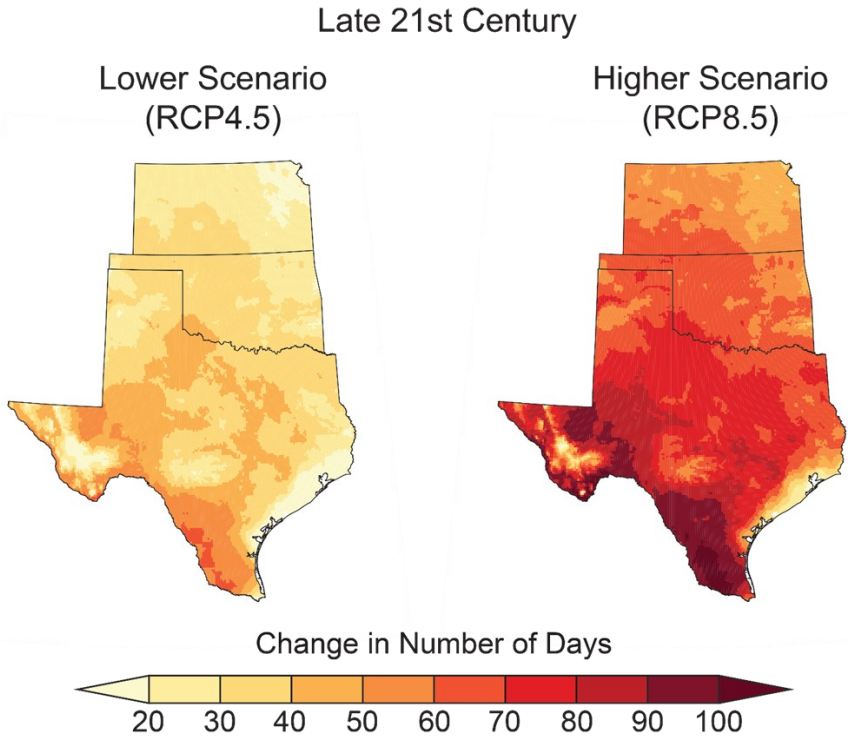


Figure 2. Projected increase in number of days above 100°F throughout the Southern Great Plains. (from Kloesel et al., 2018)

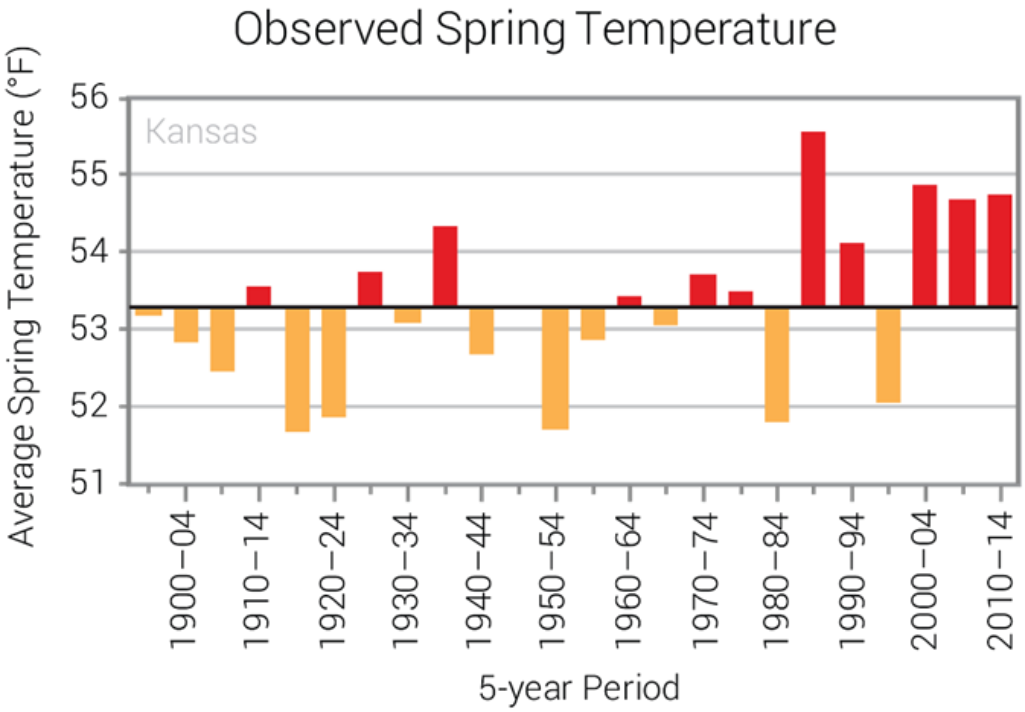


Figure 3. Warming trends in Kansas have been particularly noticeable in the spring in recent decades. (from Frankson et al., 2017)

The precipitation figure below illustrates the inherent variability and climatic challenges in our state. What has historically allowed the State of Kansas to grow and prosper is the utilization of water resources to combat extreme events. In western Kansas, groundwater resources play a critical role. In eastern Kansas, surface water resources have a more significant impact. However, these vital resources have a threshold. The State supports extensive monitoring, such as the streamgaging partnership with the USGS, to evaluate historical events and assess when current conditions are approaching a critical point. These efforts help us to understand how extreme events have impacted Kansas in the past and project how they may continue to do so in the future.

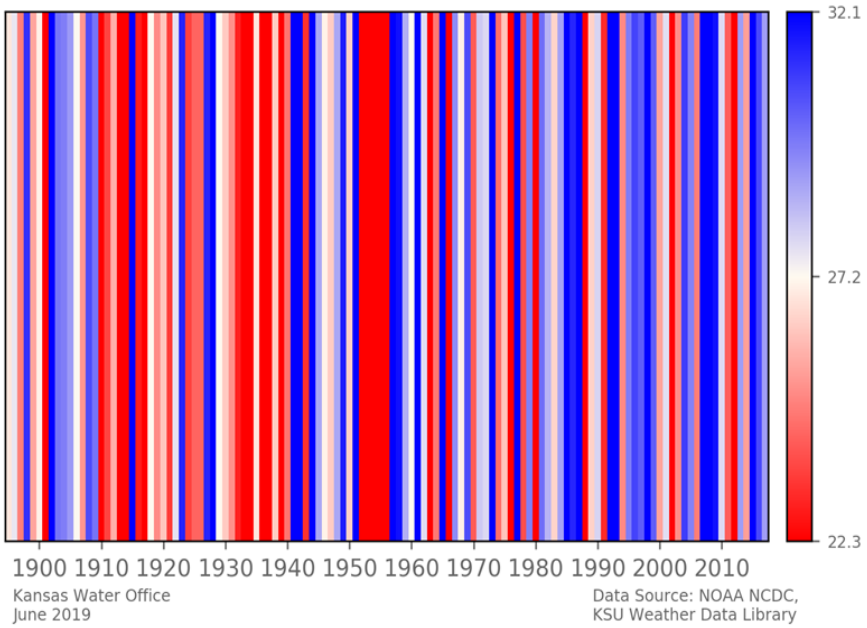


Figure 4. Statewide annual precipitation, inches (1895-2017).
Blue stripes indicate years with above average precipitation (>27.2”) and red stripes indicate years with below average precipitation (<27.2”) . The variation in color patterns demonstrates the diverse range of water resource conditions, both in duration and frequency of wet and dry conditions, that Kansas experiences.

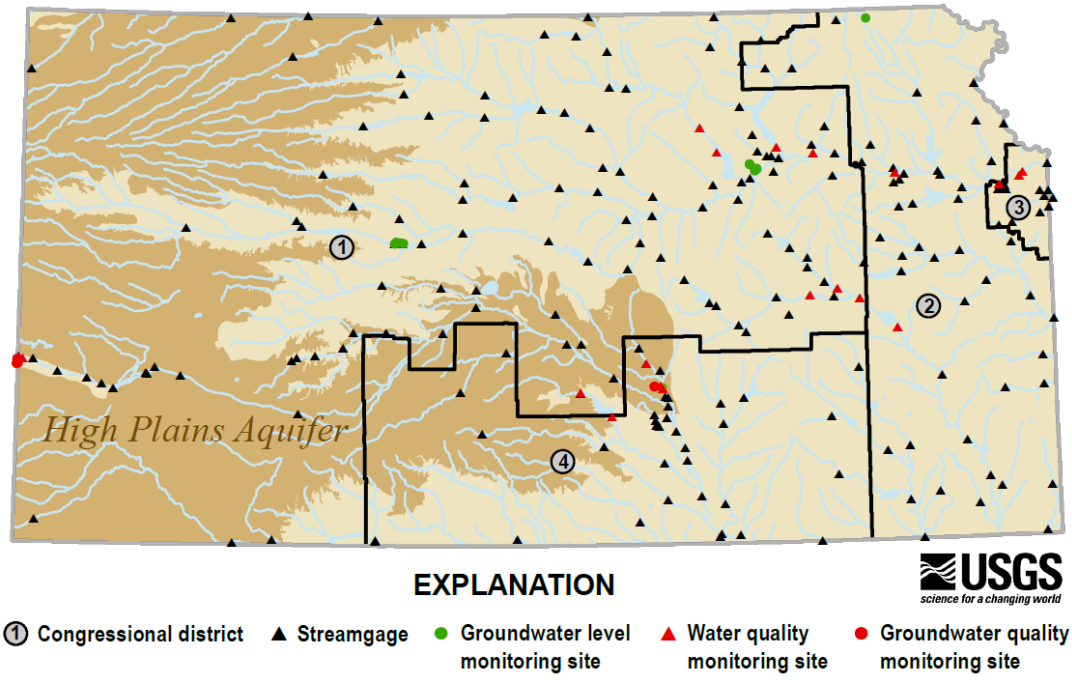


Figure 5. USGS monitoring network in Kansas. (from Painter et al., 2017)

Flooding in Kansas

Flooding usually occurs quickly when precipitation exceeds infiltration and then exceeds channel capacity. Preparations to warn of flooding, protect infrastructure, and keep sediment and nutrients from entering water bodies can decrease adverse effects and duration of any impacts. Intense precipitation events also increase the presence of sediment, nutrients, and various pollution loads in streams, which end up in reservoirs that store flood waters. Once sediment enters a reservoir during a flood event, it is deposited on the lake bed, decreasing the available storage space needed to withstand future floods and droughts. Much of the state's lost storage in reservoirs can be attributed to inflows of sediment during flood control operations. Local and regional water utility infrastructure can also be at risk, threatening the delivery of safe drinking water to users.

In 2019, saturated conditions in the Great Plains early in the year were amplified by the wettest spring on record and additional summer rains. Thanks to the state's system of federal reservoirs, levees and watershed dams, we were able to concentrate most flood damage to our reservoirs and riparian corridors. This localized damage, however, came at a cost to the State. Significant water storage space was lost in our reservoirs due to the substantial sediment and debris inflows. Our low-lying riparian areas, often accompanied by productive farm ground, public infrastructure, and other assets, endured long periods of inundation and the erosive forces of flood waters.

During the 2019 flood disaster, the Kansas Department of Agriculture's Division of Water Resources (DWR) reported only 10.0% of homes within Kansas' mapped floodplains were carrying flood insurance through the National Flood Insurance Program (NFIP). They also reported that the 287 NFIP claims made in Kansas during that time totaled $3.78 million. Floodplain maps provide guidance for local land use planning. However, other considerations often take precedence when development occurs in floodplains. Mapping these flood prone areas is an ongoing effort that requires in-depth analysis of floodplain characteristics, fluvial morphology, and planning for increased flood magnitudes. Ultimately, the effectiveness of real-time hydrology information is reliant on our ability to share the information with multiple user groups.

Figure 6. Flooding in Elmdale, KS - May 8, 2019
Photo taken by Chase County Emergency Management Director Scott Wiltse.

Additionally, the State oversees the permitting, construction, and inspection of our smaller watershed reservoirs. As these structures age, they become less functional and a potential breach danger to downstream residents if not properly maintained. Water utilities tend to be vulnerable to flood events due to their proximity to surface water resources. Water treatment intakes may be compromised by a blockage or loss of power. Wastewater systems can be overwhelmed by stormwater entering municipal sewer systems and may also be over-topped by adjacent floodwater. The development of vulnerability assessments and emergency plans is key to minimizing these disruptions of safe water to Kansans. Managing a flood event requires well-developed procedures for communication between forecasting agencies, emergency responders, government officials, utility providers, and the general public. Real-time information on weather, stream flow, reservoir storage, levee integrity and others are used to inform the State's emergency operations. The Kansas Division of Emergency Management (KDEM) provides guidance for hazard response in the 2017 Kansas Response Plan and information on mitigation in the 2018 State Hazard Mitigation Plan.

Drought in Kansas

Each year, drought costs the United States an average of $8-9 billion, as estimated by the USGS. Kansas is one of the many states with a history of significant impacts from drought. In recent years, drought-related losses in Kansas have been particularly significant in agriculture. In 2017, Kansas ranked 2nd in the country for total crop acres. The total value of agricultural products sold in 2017 was $18.8 billion according to the USDA's National Agricultural Statistics Service. In 2011, however, the Kansas Department of Agriculture estimated that drought caused roughly $1.8 billion in crop losses in Kansas including the price farmers would have received for the lost production and nearly $366 million in drought-related herd liquidation to overfilled cattle livestock auction houses. Even more destructive, the 2012 drought caused more than $3 billion in drought-related crop losses in Kansas. Additionally, more than $1.3 billion in crop insurance indemnity payments for failed commodities were paid to Kansans in 2012 according to the U.S. Department of Agriculture's Risk Management Agency. More recently, though less severe, the 2018 drought resulted in a drought declaration for the majority of the state with losses throughout the Great Plains and Southwest regions of the country estimated by the NOAA National Centers for Environmental Information (NCEI) at approximately $3.1 billion.

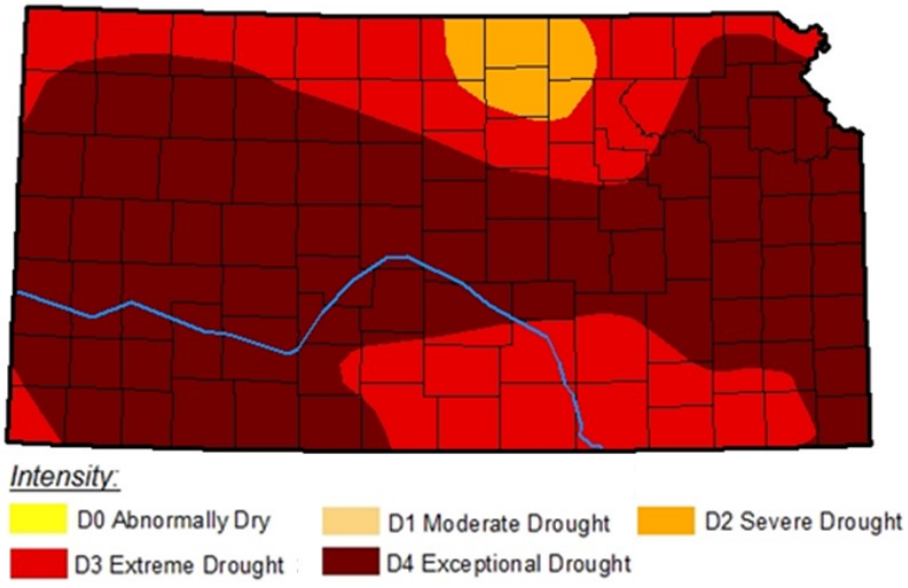


Figure 7. Kansas drought conditions in late August 2012.
(Adapted from Brewer, 2012)

Adapting to changing conditions and minimizing harm from severe droughts is vital for Kansas agriculture. The use of cover crops can help reduce vulnerability to drought by increasing soil pore space, which increases infiltration, reduces evaporation, keeps soils cooler, and positively impacts yields during drought. Additionally, no-till or strip-till farming practices, along with drought tolerant crops and decision-support tools such as irrigation scheduling and crop water allocation planning can help manage risk. Many federal and state lakes provide an alternate water supply for livestock during droughts. Whatever measures are taken, maximizing conservation practices and efficient water use during a drought is critical.

Clearly, even a single year of extreme drought can result in severe agricultural impacts. Drought impacts, however, are not limited to agriculture. Intense flash droughts can rapidly impact water supplies. With approximately two-thirds of the Kansas population relying on surface water for municipal and industrial needs, depletion of these resources creates a significant strain on communities and businesses. The Kansas Water Office recommends that water system operators monitor, plan, and coordinate to minimize drought impacts.

Municipal Water Conservation Plans:

Having a state-approved water conservation plan, through the Kansas Water Office, is a public water system's first line of defense against drought. Technical assistance for developing a plan is available through the Kansas Water Office upon request. While there is no overall requirement, a public-water supplier may be required to develop a water conservation plan as a condition of a water right, involvement in a program or as a condition of a grant. Many Suppliers recognize the value of water conservation for their community and voluntarily develop a water conservation plan. The Kansas Rural Water Association provides free technical assistance for developing municipal water conservation plans through the State Water Plan fund.

Public Water Supply Emergency Response Plans (ERPs):

KDHE requires the development of these plans to address all threats to a public water supply and steps to restore the safe delivery of water following a natural or man-made disaster. Drought plans are currently not a requirement, but a suggested action plan of the ERP.

For communities using a common source of supply, drought plans should be consistent in use restrictions to minimize political issues of fairness and equity. Alternate supplies also need to be developed for Public Water Supply (PWS) systems vulnerable to drought.

Ultimately, drought mitigation planning is needed by all sectors that use water. Additional storage of water in reservoirs or aquifers would give Kansans greater ability to manage for potential changes in precipitation timing, duration, and frequency, such as extended dry spells. This can be accomplished through conservation practices to extend and conserve groundwater resources, building or purchasing additional storage, or the recovery of existing surface storage lost to sedimentation. All potential options for drought mitigation should be pursued to protect Kansans and the future economic health of the State.

Management Approach

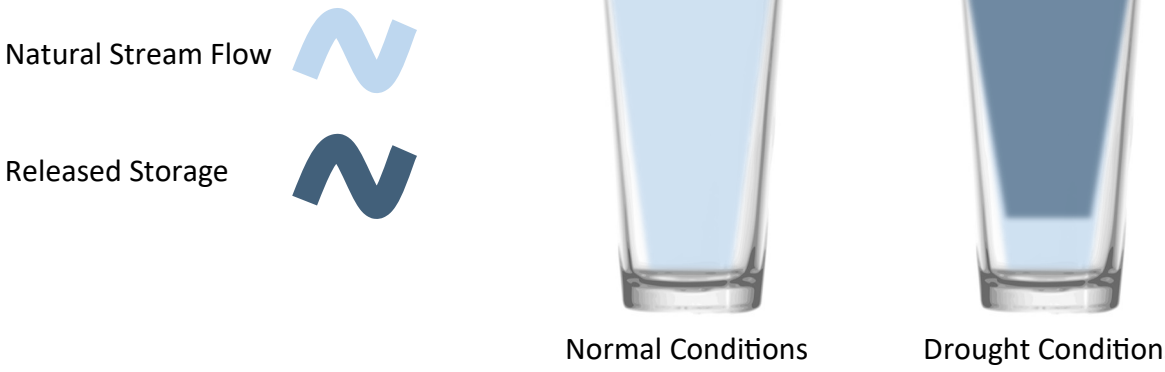
Kansas relies heavily on access to surface and subsurface water resources for everyday use. When managing through extreme events, these storage resources play a critical public safety role in fighting drought or holding back flood water.

Partnership with our Federal Reservoirs

The United States Army Corps of Engineers (USACE) and the United States Bureau of Reclamation (USBR) operate the State's federal reservoirs primarily for flood control. During a flood event, reservoir operations by these federal agencies are designed to minimize flood damage to entire basins across multiple states.

All 24 federal reservoirs also provide critical water supply during times of drought. The majority of water supply in USBR reservoirs is used to meet irrigation demands, generally in western and central Kansas. USACE reservoirs are predominantly in the East and are primarily used to satisfy municipal and industrial needs. These are operated cooperatively between the USACE and the Kansas Water Office. During drought, the majority of flow in a river is actively managed with prescribed releases from USACE reservoirs, often providing the majority of water to your tap.

Supplementing Surface Water Supply



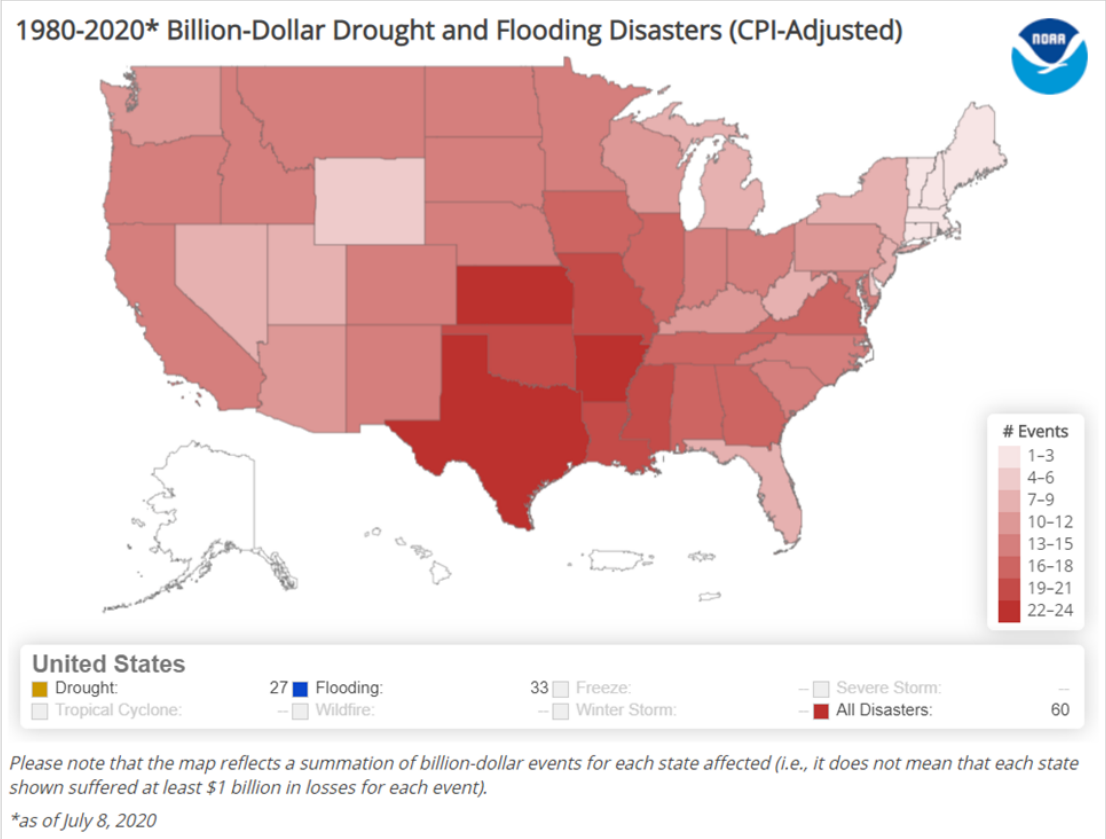
Managing Drought

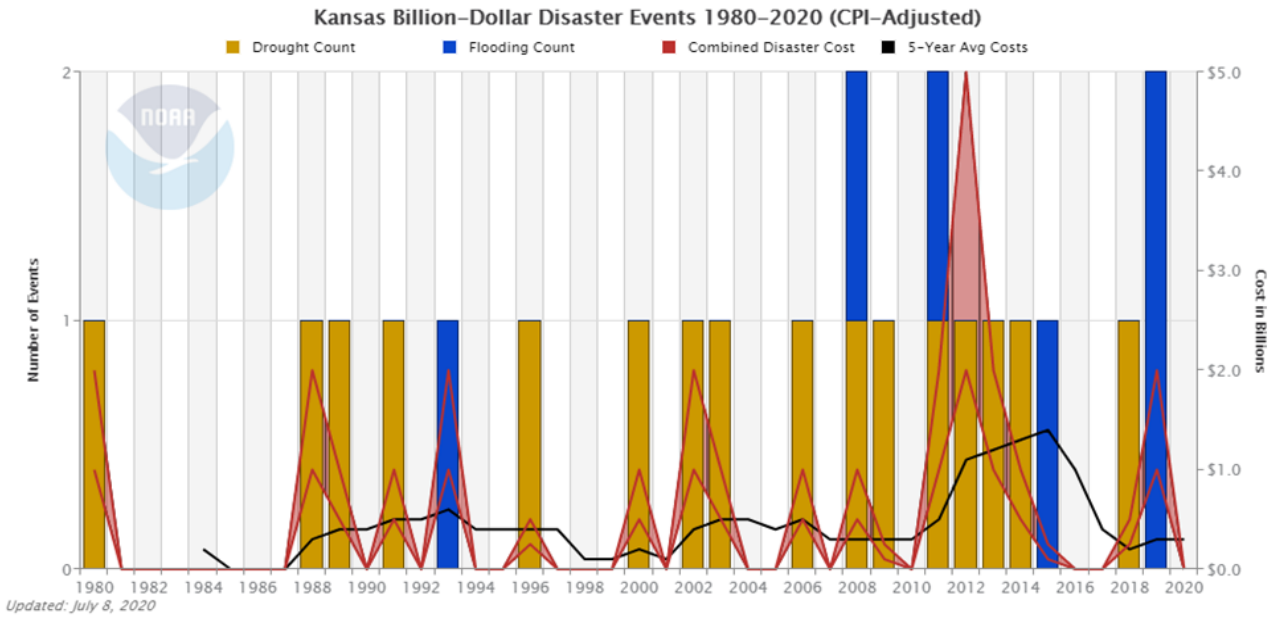
In addition to the management of reservoir storage, the State utilizes stream gages, including the USGS streamgage network, to monitor water supply. The use of Kansas water resources in times of shortage is guided by the Kansas Water Appropriation Act and the State Water Plan Storage Act. The State also maintains a Drought Response Team that is charged with monitoring conditions, coordinating resources, and supplying the Governor's Office with updates or recommendations to deploy additional resources as needed.

Assessment, Prevention, and Recovery

The State of Kansas has developed programs within multiple agencies tasked with floodplain management and mapping, non-federal dam safety, flood control lake development, disaster response planning, hazard mitigation, and others. Additionally, the State engages with many federal agencies that supply information on weather forecasts, river conditions, damage estimates, and disaster relief for qualified applicants.

Measuring Success





In Kansas, our best measure for extreme event resiliency is economic impact. A high economic impact from flooding or drought would suggest a vulnerability or inability to withstand such an event. From 1980 to 2019, 6 Flooding and 16 Drought billion-dollar disaster events affected Kansas (CPI-adjusted). Weather and climate disaster statistics are collected and distributed by NOAA's National Centers for Environmental Information. Assessment data are provided by a number of sources including insurance companies and State and Federal agencies.

Recommended Actions

In response to the increasing frequency of natural disasters across the country, federal assistance programs are shifting focus to projects that reduce or eliminate the risk of repetitive damage. The National Institute of Building Sciences has found that the economic benefits of hazard mitigation significantly outweigh the costs by as much as 6:1 when using traditional cost-benefit analysis. Typically, federal programs require a portion of State or local cost share. This effort to spend federal dollars more efficiently has created a competitive environment among states to put forth well-informed and partially funded mitigation projects. These projects require stakeholder engagement, planning, engineering, and capital. It is critical that the State of Kansas engage in this process if we wish to join our neighboring states and minimize extreme event impacts in the future.

Recommended Actions and Strategies - Flood

Policy or Program Recommendations

- Improve collaboration between state, federal, and public stakeholders and encourage pooling of resources to enhance flood planning and response.
- Pursue better coordination of data sharing and public information.

Implementation Actions

- Assemble a group of subject experts to identify the areas of greatest need and opportunity, improve flood planning and response, and determine the best path forward.
- Compile critical flood information currently spread across several agencies into a single, publicly-accessible location with a user-friendly interface.
- Continue the development of real-time flood inundation mapping in Kansas.
- Work with state and federal agencies and emergency managers to develop a methodology for assessing damages to stakeholders from floods in a timely manner.
- Develop flexible reservoir management strategies that provide the ability for precautionary drawdowns if there are indications of coming flood conditions.
- Promote the use of dry dams and flood easements to temporarily hold flood water behind roadways or other opportunistic land features.

Data, Research, and Studies

- Work with state and federal partners to identify existing data gaps, including needs for additional gages within the monitoring network to improve river forecasting.
- Continue the development of advanced flow modeling for future flood planning, and identify basins lacking the data necessary to support more sophisticated modeling methods.
- Evaluate past climate and stream gage data, current climate trends, and projections for extreme event frequency, size, and duration in Kansas to update flood planning based on such statistics as appropriate.
- Support efforts to improve forecasting to predict extreme conditions and pursue flexible reservoir management strategies that maximize the benefit of such information.

Funding and Resource Needs

- Shift focus from reactionary to preventative, emphasizing mitigation efforts that reduce or eliminate the risk of repetitive flood damage, and be more competitive for funding from federal assistance programs.
- Determine existing infrastructure needs to repair damage from past floods and prevent additional losses from occurring in the future.
- Work with federal partners to maximize matching funds and pursue cost-effective measures that address data and infrastructure needs.

Recommended Actions and Strategies - Drought

Policy or Program Recommendations

- Prioritize the conservation and maintenance of existing water storage, both surface water and groundwater, to ensure sufficient supply under future drought conditions.
- Ensure sufficient staff and in-state expertise to optimize drought planning strategies.
- Develop and promote new drought mitigation tactics for water managers to utilize through an updated water conservation planning document.

Implementation Actions

- Develop sediment management plans for water supply reservoirs, emphasizing sustainability and the preservation of existing storage.
- Develop flexible reservoir management strategies that provide the ability to eliminate drawdowns and increase water storage if there are indications of coming drought conditions.
- Utilize BMPs and conservation practices, such as cover crops, no-till or strip-till, drought-tolerant crops, irrigation scheduling and crop water allocation planning to prepare for and reduce negative impacts from drought.
- Make drought plans a mandatory component of emergency plans.
- Update water conservation plan guidelines and ensure all communities and rural water districts have current water conservation and drought management plans.
- Educate landowners on the importance of groundwater conservation, the need for sustainable practices, and encourage participation in existing programs.

Data, Research, and Studies

- Investigate and pursue innovative sediment management technologies, such as Water Injection Dredging (WID) and hydrosuction, to preserve reservoir storage.
- Improve forecasting to predict extreme conditions and pursue flexible reservoir management strategies that maximize the benefit of such information.
- Evaluate past climate and stream gage data, current climate trends and, projections for extreme event frequency, size, and duration in Kansas to update drought planning based on such statistics as appropriate.
- Develop advanced models that incorporate climate variability modeling into the water supply model to optimize drought planning strategies.

Funding and Resource Needs

- Work with federal partners to maximize matching funds and prioritize funding for the development of sediment management plans and sediment management pilot projects.
- Expand in-state expertise related to drought forecasting, modeling, and planning and secure sufficient funding to address any staffing needs that are identified.
- Pursue funding necessary to assist and incentivize landowner participation in groundwater conservation programs.

Actions should consider both short and long-term economic and environmental impacts to communities, agriculture producers, the energy sector, transportation infrastructure, and our recreation facilities. Ultimately, reducing vulnerability to extreme events in Kansas is best accomplished by acknowledging the risks and mitigating likely impacts from flooding or drought. This requires plans and actions that will assure the safety of our citizens and provide a clean, sufficient water supply to Kansans.

References

Layzell, Anthony L., and Catherine S. Evans. *Kansas droughts: Climatic trends over 1,000 years*. Kansas Geological Survey, Geology Extension, University of Kansas, http://www.kgs.ku.edu/Publications/PIC/PIC35r.pdf. 2013.

NOAA National Centers for Environmental Information, State of the Climate: Drought for June 2011, published online July 2011, retrieved on October 22, 2020 from https://www.ncdc.noaa.gov/sotc/drought/201106.

Kloesel, K., B. Bartush, J. Banner, D. Brown, J. Lemery, X. Lin, C. Loeffler, G. McManus, E. Mullens, J. Nielsen-Gammon, M. Shafer, C. Sorensen, S. Sperry, D. Wildcat, and J. Ziolkowska, 2018: Southern Great Plains. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 987 –1035. doi: 10.7930/NCA4.2018.CH23. https://nca2018.globalchange.gov/chapter/23/.

Frankson, R., K. Kunkel, L. Stevens, D. Easterling, X. Lin, and M. Shulski, 2017: Kansas State Climate Summary. *NOAA Technical Report NESDIS 149-KS,* 4 pp. https://statesummaries.ncics.org/chapter/ks/

Painter, C.C., Kramer, A.R., and Kelly, B.P., 2017, Groundwater and streamflow information program Kansas Cooperative Water Science since 1895 (ver. 1.3, October 2019): U.S. Geological Survey General Information Product 176, 2 p., https:// doi.org/10.3133/gip176.

Painter, C. "Kansas Drought." *USGS,* https://www.usgs.gov/centers/kswsc/science/kansas-drought?qt-science_center_objects=0 .

United States Department of Agriculture. "National Agricultural Statistics Service." https://www.nass.usda.gov/index.php.

Bickel, Amy. "End of Dry Conditions on Horizon for Some in Kansas." *The Topeka Capital-Journal*, 12 Apr. 2013, www.cjonline.com/article/20130412/NEWS/304129818.

NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2020). https://www.ncdc.noaa.gov/billions/, DOI: 10.25921/stkw-7w73

Brewer, Michael. "U.S. Drought Monitor, Kansas, August 21, 2012." *NCEI/NOAA*. Released August 23, 2012. https://droughtmonitor.unl.edu/data/pdf/20120821/20120821_ks_trd.pdf